

UPPER PERMIAN INSECTS OF NEW SOUTH WALES. III.

THE ORDER COPEOGNATHA.

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(With thirteen Text-figures.)

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This paper is a continuation of the series which I began in 1926 (Tillyard, 1926*a*) with a paper dealing with the Upper Permian fossil insects of the Order Hemiptera, and followed with a second part (Tillyard, 1926*b*) on the Orders Mecoptera, Paramecoptera and Neuroptera. During the intervening nine years, a very large number of new fossil insects have been discovered in Upper Permian rocks from Warner's Bay, thanks to the persistent labours of Messrs. T. H. Pincombe, M. S. Stanley, Rev. A. J. Barrett and myself; to whom must be added more recently Master Malcolm Stanley, who in the course of a year or so has discovered quite a considerable number of fine wings.

The insect fauna of the Upper Permian in New South Wales, as now presented to us from a study of about five hundred specimens, is a very remarkable one for a Palaeozoic Fauna. Most of the older types of insects are either absent or very rare. Orthopteroid insects of all kinds appear to be entirely absent, including Cockroaches. No Palaeodictyoptera, Megasecoptera or Mayflies have been found, and only a single larva of definite Perlarian affinity. Dragonflies are so far represented only by two or three fragments of a wing which appears to belong to the family Ditaxineuridae, known only from the Lower Permian of Kansas. The Suborder Homoptera of the Order Hemiptera was the dominant group. As these insects must have fed mainly on *Glossopteris*, their remarkable abundance must be taken into account as a possible factor in the decline and eventual disappearance of the *Glossopteris* flora at the close of the Upper Permian. Closely related to the Homoptera, and by no means uncommon, were the members of the Order Copeognatha or Psocoptera, dealt with in this Part.

Apart from the above Hemimetabolous Insects, the fauna is mainly composed of Holometabola and their ancestors. Quite a number of new and interesting types of Coleoptera have been discovered, together with further representatives of the Order Protocoleoptera. Next to the Homoptera, the most abundant Order of Insects was the Mecoptera or Scorpion-flies, of which many new types have been found. The derived Order, or Sub-order, Paratrachoptera is represented by quite a number of primitive genera, and these in turn had already produced, alongside of them, true representatives of the Order Diptera. The only other Order known for certain from these beds is the Neuroptera Planipennia, of which a number of very fine new types have been discovered. There is one wing, which is unfortunately very fragmentary, which may belong to some primitive type of Hymenopteron, but this is not at all certain.

The present Part deals with the Order Copeognatha only, and presents for the first time a Copeognathous fauna of great richness and variety which is evidently a marked advance on that of the Lower Permian of Kansas.

Order COPEOGNATHA.

The earliest known representatives of this Order come from the Lower Permian of Kansas, and were described by me in 1926. Two families are there represented, viz., the Dichentomidae and the Permopsocidae. So far, no Copeognatha have been described from the Upper Permian of New South Wales. But, in the more recent collections from Warner's Bay, this Order proves to have been well represented by more than twenty specimens. Unfortunately the conditions of fossilization are generally such that the wings become badly crumpled or torn. This is particularly the case with a fine species belonging to the family Dichentomidae. I have before me several specimens of which I am quite unable to give descriptions. Not only are the wings torn or crumpled, but it is evident from the habit of this insect of resting (and, evidently, also dying) with its wings held close together in a steep roof-wise position, either all four wings, or sometimes only two, became stuck together in the glue-like mud in which they were preserved, leaving impressions of either four or two very faint systems of venation, crossing one another at slight angles, and making it impossible to restore the venation as it originally was.

So far, the family Permopsocidae has not been discovered in the Upper Permian beds of Australia; unless, perhaps, the new genus *Megapsocidium* should happen to belong to this family, when the structure of its cubitus is revealed. The Dichentomidae are well represented, and there are also two remarkable new families possessing quite unexpected types of venation. One of these, the Zygopsocidae, would appear to be a specialized group which has left no descendants. But the other, the Zoropsocidae, proves to be of special interest for two reasons: firstly, it appears to represent the ancestral stock of the recent Suborder Zoraptera, now confined to the nests of Termites; and, secondly, it supplies a connecting link between the more typical Copeognatha and the family Lophioneuridae (inclusive of Dr. F. M. Carpenter's family Cyphoneuridae), which can now be shown to be true Copeognatha and not Homoptera as we both originally supposed. Included in the present collection are a number of new genera allied to both *Lophioneura* and *Cyphoneura*. Some of the specimens are practically complete, and prove to be insects having the general character of Copeognatha, with depressed head, hypognathous mouth-parts, no sign of a sucking-beak, wings held roof-wise over the back, and other characters of the Order. It is therefore now necessary for me to remove the family Lophioneuridae from the Homoptera and to include it in the Copeognatha. It will further be abundantly evident that Carpenter's family Cyphoneuridae (Lower Permian of Kansas) cannot stand, but must be merged with the Lophioneuridae.

The Copeognatha of the Permian now prove to have been quite abundant in families, genera and species. They are evidently very closely allied to the Homoptera, and there can be no doubt that the two groups arose from a common stem. Apart from the very obvious differences in the shape of the head and the structure of the mouth-parts, it is possible to distinguish the wings of the Permian Copeognatha at once by the fact that Rs is always branched, whereas in the Permian Homoptera Rs is always simple (except for short terminal branchlets in the abundantly-veined Prosbolidae).

In the figures of this paper, except only figs. 7A and 9, which are complete insects, the wings are drawn always with apices to the right, to facilitate comparison.

Key to the Families of Permian Copeognatha. (Forewings only.)

1. Rs with four branches arranged in an anteriorly pectinate series Family *Zygopsocidae*, n. fam.
Rs with less than four branches, not arranged as above 2
2. M three-branched; Cu₁ forked or simple Family *Dinopsocidae* Mart.
(Upper Permian of Russia only.)
M with either four or two branches 3
3. M four-branched; Cu₁ forked 4
M two-branched; Cu₁ usually simple, rarely with a weak posterior branch 5
4. Fork of Cu₁ deep and strongly arched, connected with M₃₋₄ above by a cross-vein Family *Permopsocidae* Till.
(Lower Permian of Kansas.)
Fork of Cu₁ less arched, often long and flat, not connected with M₃₋₄
..... Family *Dichentomidae* Carp.
(Lower Permian of Kansas and Upper Permian of Australia.)
5. Main veins more or less strongly curved, Cu₁ sigmoidally; Rs, M and Cu₁ arising separately from R₁ Family *Lophioneuridae* Till.
(Upper Permian of Australia and Lower Permian of Kansas.)
Main veins normal, Cu₁ not sigmoidally curved; their modes of origin also normal Family *Zoropsocidae*, n. fam.

Family 1. DICHENTOMIDAE Carp.

Psocidiidae, Tillyard, 1926c, p. 319.—Dichentomidae, F. M. Carpenter, 1932, p. 3.

Dr. Carpenter considers the genus *Psocidium* Till. to be synonymous with *Dichentomum* Till. As the latter takes page precedence, the name of the family should be changed to Dichentomidae. Pending a restudy of the types, I think that this alteration should stand. The two genera are in any case very closely allied.

There are three new generic types in the material before me, which may be distinguished as follows:

1. Medium-sized wings with the branches of Rs arising distad from the level of the end of R₁ 2
Large wings with the branches of Rs beginning at a level well before the end of R₁ Genus *Megapsocidium*, n.g.
2. Sc simple; R well removed from costa; M 4-branched in forewing Genus *Austropsocidium*, n.g.
Sc branched; R fairly close to costa; M 5-branched in forewing Genus *Stenopsocidium*, n.g.

Genus 1. AUSTROPSOCIDIUM, n.g. Figs. 1, 2.

Forewing elongate-oval in shape, the costa gently curved, the apex well rounded. Sc ending on R₁. R well removed from costa. Rs either two- or three-branched, but the branches short in any case. M four-branched, normal, connected with Rs by a radio-median cross-vein. Cu₁ arising just below M and having a long, rather flat fork not connected with M in any way. Cu₂ a straight, weak furrow-vein bounding a small but well developed anal area or clavus with two anal veins; 1A nearly straight, close to Cu₂; 2A slightly sigmoid.

Genotype: *Austropsocidium pincombei*, n. sp.

Horizon.—Warner's Bay. Upper Permian of New South Wales.

Key to the Species of the Genus Austropsocidium.

- Rs two-branched, R₁ without strongly marked pterostigma *A. pincombei*, n. sp.
Rs three-branched, R₁ with large strongly marked pterostigma .. *A. stigmaticum*, n. sp.

1. *AUSTROPSOCIDIUM PINCOMBEL*, n. sp. Fig. 1A, 1B.

This specimen consists of fore and hind wings lying one upon the other, the apices being to the left. The venation of the forewing is not difficult to make out, but that of the hindwing, being fainter, is more difficult to trace. In the figures, the wings have been separated.

Forewing (fig. 1, A).—Length 7.9 mm.; breadth 2.8 mm. Membrane very delicate; venation faint except for the anal veins. Sc very faint basally but clearer as it approaches its junction with R_1 , which it does with a slight downward curve. R_1 forked distally but with little or no formation of a pterostigma. Rs arising at about one-third and forking into two just beyond the level of the end of R_1 . M arising from R at about one-fifth and forking a little beyond middle of wing; the upper fork, M_{1+2} , is connected with Rs by a cross-vein after arching strongly upwards; its fork is at the same level as that of Rs. Fork of M_{3+4} slightly basad from that of M_{1+2} . Cu_1 running basally just below $R+M$ and leaving it just before M, descending obliquely to fork somewhat before half-way along the wing; the long, flattish fork reaches to just beyond the level of the fork of M_{3+4} . 1A and 2A strong veins on a well formed clavus with slightly convex posterior margin.

Hindwing (fig. 1, B).—Length 6.4 mm.; breadth 2.5 mm. Differs from forewing in the much narrower costal area and much wider space between R_1 and Rs. R_1 unbranched. Stem of M_{3+4} much shorter than in forewing. Arch of Cu_1 flatter than in forewing, with Cu_{1b} placed more obliquely. Clavus smaller, apparently with only a single anal vein, 1A, present.

Type.—*Holotype*, Specimen P. 218, found by Mr. T. H. Pincombe at Warner's Bay, 23rd October, 1926. This was the first Psocid wing discovered in the Upper Permian beds of Australia.

2. *AUSTROPSOCIDIUM STIGMATICUM*, n. sp. Fig. 2.

This species is only represented by the distal two-thirds of a rather long, slender wing, obviously a forewing, the apex to the left.

Length of fragment 6.6 mm., representing a total length of about 9.5 mm. Breadth 2.6 mm.

Sc not visible. R_1 widely forked, forming a rather long, triangular pterostigma, distinctly pigmented. Rs almost straight, forking into three short terminal branches well beyond level of pterostigma. M running parallel to Rs and forking rather narrowly below level of pterostigma; upper branch, M_{1+2} , continues almost parallel to Rs and connected with it by a perpendicular cross-vein, rm, before the fork; lower branch, M_{3+4} , diverging slightly and forking just before level of end of pterostigma. Cu_1 forking only slightly before level of fork of M, and not so long or flat as in *A. pincombei*.

Clavus and anal veins missing.

Type.—*Holotype*, Specimen found by Rev. A. J. Barrett at Warner's Bay in 1930.

Genus 2. *MEGAPSOCIDIUM*, n.g. Fig. 3.

Differs from *Austropsocidium* in having R_1 and Rs connected by a cross-vein below the fork of R_1 and in having Rs forking strongly at this cross-vein and again forked distally on the upper branch. Only the distal third of the wing is preserved, but it appears as if the four branches of M were not normally arranged, there being three branches on M_{1+2} and M_{3+4} being unbranched.

Genotype, *Megapsocidium australe*, n. sp.

Horizon.—Warner's Bay. Upper Permian of New South Wales.

3. MEGAPSOCIDIUM AUSTRALE, n. sp. Fig. 3.

This specimen consists of the distal half only of a forewing (apex to the right), measuring 6.0 mm. long by 3.5 mm. wide, and probably representing a wing of total length 10 mm. or more. The apical portion is complete, but the basal break is very irregular and there is also an irregular patch of rather large size broken away from the centre.

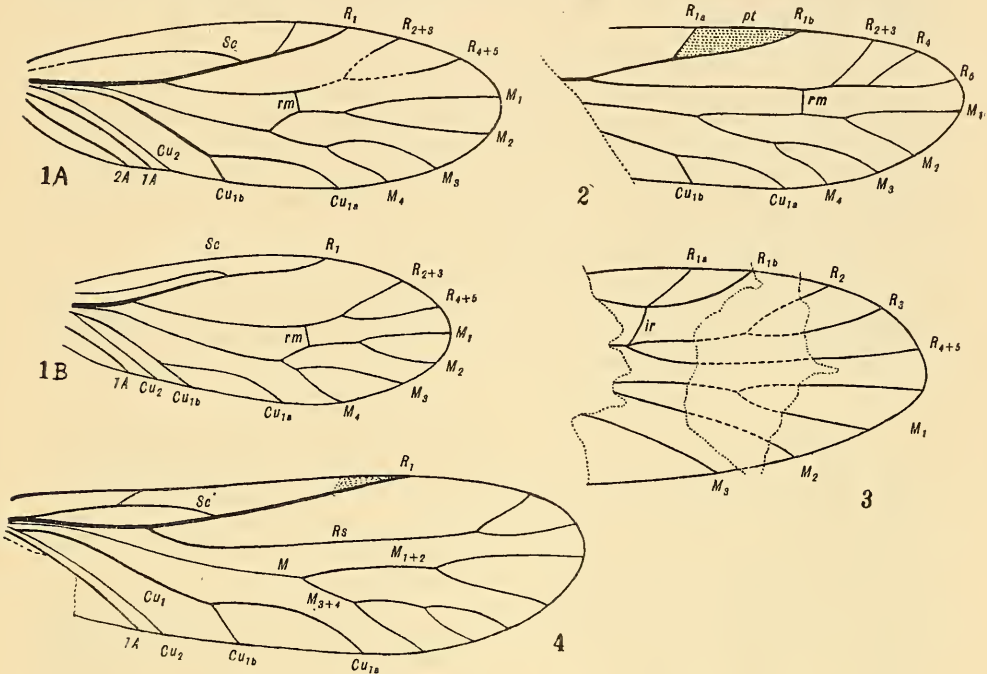


Fig. 1.—*Austropsocidium pincombei*, n.g. et sp. A, Forewing (7.9 mm.). B, Hindwing (6.4 mm.). Both with apex turned to right. Family Dichentomidae.

Fig. 2.—*Austropsocidium stigmaticum*, n. sp. Distal half of forewing (6.6 mm.) with apex turned to right. Family Dichentomidae.

Fig. 3.—*Megapsocidium australe*, n.g. et sp. Fragment of forewing (6.0 mm.). Family Dichentomidae (?).

Fig. 4.—*Stenopsocidium elongatum*, n.g. et sp. Forewing (6.5 mm.), with apex turned to right. Family Dichentomidae.

The wing is very slightly tinted pale brown, the shading being a little more marked in the region of the pterostigma, which extends downwards well below R₁. At the basal fracture, R₁ is seen diverging quite strongly from the costa, and shortly afterwards gives off an oblique veinlet R_{1a} to the costa, while its main stem continues in a strong curve as R_{1b}. At the lowest point of R_{1b}, a slightly oblique interradial cross-vein (ir) passes to R_s, which divides immediately distad of this into two main branches, of which the upper, R₂₊₃, again divides into a large distal fork. Below R_s, on the basal fracture, the stem of M₁₊₂ appears and at once divides into M₁ and M₂, the upper branch apparently again dividing into a large distal fork, though the central break in the rock-surface has eliminated the

actual point of forking. The two distal pieces of veins lying below this are almost certainly M_2 and M_4 . Cubital and anal areas missing.

Type.—Specimen B.109, found by Rev. A. J. Barrett at Warner's Bay in 1930.

This species is placed only provisionally in the family Dichentomidae, as the form of its cubital area is not yet known. It is conceivable that the genus *Megapsocidium* may in the end prove to be the Upper Permian Australian representative of the family Permopsocidae, which would otherwise be missing from this fauna.

Genus 3. STENOPSOCIDIUM, n.g. Fig. 4.

Wings narrow elongate-oval in shape, the costa nearly straight to end of R_1 , the apex well rounded. Sc ending on R_1 but having also a branch veinlet to costa. R not far removed from costa, simple. Rs two-branched, the branches short, terminal. M five-branched in forewing, four in hind. Cu_1 with a long, flattish fork, not connected with M in any way. Cu_2 an extremely faint furrow-vein. 1A strong, nearly straight. (2A missing.)

Genotype, *Stenopsocidium elongatum*, n. sp.

Horizon.—Warner's Bay. Upper Permian of New South Wales.

This interesting genus is fairly closely allied to *Austropsocidium*, from which it differs by the narrower, more elongate wing, with simple radius placed closer to costa, Sc with a branch veinlet to costa and M five-branched in forewing.

4. STENOPSOCIDIUM ELONGATUM, n. sp. Fig. 4.

This specimen is a very faint impression on a piece of smooth shale, somewhat darker than usual for Warner's Bay. It shows the faint outline of a slender body, 4.6 mm. long, of which the parts are barely distinguishable, together with one pair of wings, also faint, the forewing overlying the hind. The basal portions of Rs and M, and also the whole of Cu_2 , are almost obliterated, but the rest of the venation can be made out in the forewing.

Forewing (fig. 4).—Length 6.5 mm.; breadth 2.0 mm. Membrane very delicate; venation very faint except for R_1 , Cu_1 and 1A. Sc arises with R and rejoins it at about one-third of the wing-length, giving off an oblique veinlet to the costa just beyond half-way. R_1 reaches the costa at a very acute angle and there is slight chitinization and darkening of the pterostigma. Rs forks well beyond level of end of R_1 . Primary fork of M lies a little beyond middle of wing; M_{1+2} forks well before level of fork of Rs; M_{3+4} has three branches, the extra one being on M_3 . Fork of Cu_1 long, covering about one-fifth of the posterior margin. Cu_2 very faint, 1A very strong; these two veins appear to be almost straight, fairly close, and slightly diverging.

Hindwing almost as long as fore, but definitely narrower basally and very slightly narrower distally. Venation too faint to be made out definitely, except in the case of R_1 , distal end of Rs, distal half of M and fork of Cu_1 . Rs forks much as in forewing, but fork a little narrower. M has only four branches, there being no extra branch on M_3 . Fork of Cu_1 apparently not so long as in forewing.

Type.—*Holotype*, Specimen B.300, found on a piece of rock collected at Warner's Bay by Rev. A. J. Barrett in 1927.

The species has such delicate wings that it is extremely fortunate that a specimen has been discovered in which the venation can be made out with fair accuracy. Several other specimens have been discovered which appear to belong to this species, but it is quite impossible to follow out the extremely faint venational scheme.

Family 2. ZYGOPSOCIDAE, n. fam.

Wings broad, the anal area with two anal veins, 1A being fused distally with Cu_2 . Cu_1 simple. Rs four-branched. M two-branched.

Genus 4. ZYGOPSOCUS, n.g. Fig. 5.

Forewing well rounded, broadest at level of pterostigma. Sc ending on R_1 just before half-way. Rs arising not far from base and again connected with R_1 by an inter-radial cross-vein (ir) beneath the end of Sc; just below this cross-vein, Rs forks, and its lower branch again forks into three branches. M arising close to base, very faint for the first fourth of its length, then becoming stronger and connected with Rs at about two-fifths by a radio-median cross-vein (rm): M then curves downwards somewhat sigmoidally and branches into two just beyond half-way. Cu very indistinct at base but apparently separated from M. Cu_1 indistinct almost to level of rm, then becoming strong and ending about half-way along posterior margin by a strong downward bend. Cu_2 and 1A united at about half their lengths to form a Y-vein which continues straight on to end on the posterior margin not far from Cu_1 but diverging slightly from it. 2A arising contiguously with 1A but diverging slightly from it and ending on the border by a slight downward curve. There is a faint indication of a humeral veinlet. Except where they are indistinct, all the veins are broad and flat, without signs of macrotrichia. The margin of the wing is fairly broadly chitinized all round, particularly in the posterior apical portion. The base of the wing was heavily chitinized.

Genotype, *Zygopsocus permianus*, n. sp.

Horizon: Warner's Bay. Upper Permian of New South Wales.

5. ZYGOPSOCUS PERMIANUS, n. sp. Fig. 5.

Forewing.—Length 4.7 mm.; breadth 1.8 mm. Apex to the right. A practically perfect wing but with the veins rather faintly impressed on the rock. Apart from a dark patch at the extreme base and slight darkening of the pterostigma, the colouring was confined to the veins, the darkened portions being the forks of Rs and M and 1A around its fusion with Cu_2 ; the costal margin is also darkened from near base to apex.

Type.—*Holotype*, Specimen B.107, found by Rev. A. J. Barrett at Warner's Bay in 1930.

Besides the type, there are two other specimens which belong to this genus and probably to this species. One is a nearly complete insect showing a distorted and indistinct head, but with the thorax, forelegs and abdomen complete, and obviously a mature female. The foreleg has a rather wide, flattish femur, 0.6 mm. long, the tibia 1.0 mm. long, slender, the tarsus short, 0.25 mm., apparently consisting of three short segments. The head appears to have been large and pear-shaped, the compound eyes rather small and not prominent, the mouth-parts hypognathous and very prominent, but these and parts of the antennae are badly preserved. Thorax with rather short, wide pronotum; meso- and metanota subdivided into two lateral portions and a large subtriangular scutellum. Wings extending at an angle on either side of the body, but the left wing crumpled and the right forewing incomplete; portion of the left hindwing lies across the body, showing a very wide fork on M. Abdomen broadly fusiform but the segmentation rather indistinct. The other specimen is an incomplete forewing, showing the regions of R and M, but with the posterior margin folded or crumpled.

Family 3. ZOROPSOCIDAE, n. fam.

Wings narrow, the anal area reduced and having only one anal vein, 1A. Cu_2 short; Cu_1 unbranched. Rs and M both only two-branched. Origins of veins Rs, M and Cu_1 normal; a weak cubito-medial Y-vein may be present.

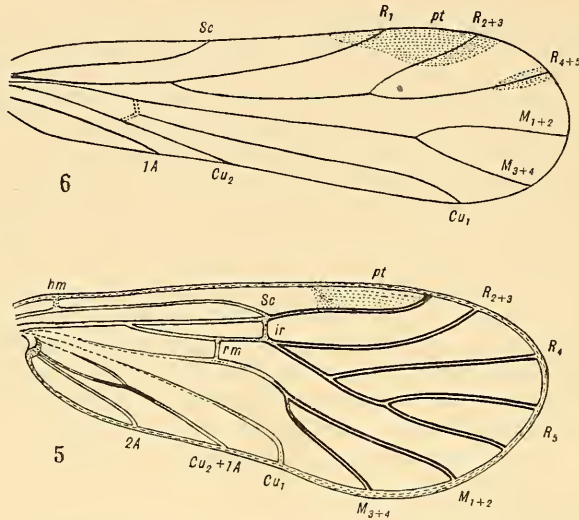


Fig. 5.—*Zygopsocus permianus*, n.g. et sp. Forewing (4.7 mm.). Family Zygopsocidae.

Fig. 6.—*Zoropsocus delicatulus*, n.g. et sp. Forewing (2.5 mm.). Family Zoropsocidae. Apex turned to the right.

This interesting family appears to stand at the base of two very curious groups, one fossil and one recent. On the one hand, it evidently represents the more primitive ancestral type from which the Lophioneuridae have been derived by movement of the points of origin of Rs, M and Cu_1 along R and also by specialized curvature of these veins; on the other, it would appear to represent the type of wing from which the recent Suborder Zoraptera must have been derived long ago, before it took on the specialized habit of living in the nests of Termites. Wings in recent Zoraptera are only of secondary importance, and the great majority of the specimens found are apterous. In the rare winged forms, the venation is greatly reduced and has only with some doubt been referred to the Copeognathous type. The Zoropsocidae are very small insects having wings of about the same size and shape as those of the Zoraptera. In both, the basal part of the wing is narrow and the apical portion widened, the apex itself being well rounded; the pterostigmatic area is long and well chitinized. But, in the Zoraptera (genus *Zorotypus* Silv.), Rs and M are both simple veins and are fused for some distance in the middle of the wing; the cubito-medial Y-vein has been lost and the main stems of M and Cu_1 have become united; and, finally, the anal vein, 1A, has either become completely lost or, possibly, fused for most of its length with Cu_1 . These characters indicate that *Zorotypus* stands far in advance of the Zoropsocidae; but they also show that there are no characters in which the Zoraptera could not have been directly descended from the Zoropsocidae, except only in the possibly branched Cu_1 . If the basal short

branch of this vein in *Zorotypus* really represents either the free end of a partially fused 1A, or perhaps the free end of Cu_2 , then the whole venational scheme of *Zorotypus* is directly derivable from that of *Zoropsocus*, n.g., by reduction.

Genus 5. *ZOROPSOCUS*, n.g. Fig. 6.

Wings much narrowed at base, widest in the region of the distal portion of the pterostigma. Costa and posterior margin fairly straight, apex well rounded. Sc short, ending at about one-third along costa. R_1 simple, ending at about two-thirds on costa. Both branches of Rs ending before apex. Pterostigma chitinized, covering both R_1 and R_{2+3} . M long and straight, forking at a level somewhat distad from that of the fork of Rs. Cu_1 long and only slightly curved distally, ending beyond the level of the fork of M. Cu_2 ending just beyond one-third. A weak cubito-median Y-vein present. 1A straight, diverging very slightly from Cu_2 . Posterior margin of wing only slightly curved basally.

Genotype, *Zoropsocus delicatulus*, n. sp.

Horizon.—Warner's Bay. Upper Permian of New South Wales.

This very remarkable genus stands well apart from all known fossil and recent Copeognatha and certainly required the establishment of a new family to contain it. It would appear to represent the type of wing from which the recent Suborder Zoraptera may have been derived by further reduction of the venation. The size and shape of the wings are about the same, both being narrow basally and widest towards the well-rounded apex. Both have the pterostigma long and well chitinized. But in the Zoraptera (genus *Zorotypus* Silv.) the veins Rs and M are both simple and are anastomosed for some distance in the middle of the wing; the cubito-median Y-vein has been lost and the main stems of M and Cu are united; finally, the anal area and vein 1A have been entirely lost, or 1A may be fused with Cu_1 .

6. *ZOROPSOCUS DELICATULUS*, n. sp. Fig. 6.

Forewing.—Length 2.5 mm.; breadth 0.6 mm. Apex to the left. The wing is tinged with brownish along costa and more especially at distal end of pterostigma, which is irregularly shaped as in figure 6. The cubito-median Y-vein is very indistinct. All the veins are rather lightly chitinized but carry the sockets of numerous macrotrichia fairly regularly placed in a single row along each vein.

Type.—*Holotype*, Specimen S.29, found by Mr. Stanley in rock collected at Warner's Bay in 1934.

Specimen P.215, found by Mr. Pincombe at Warner's Bay in 1933, appears to belong to this species also. It is a forewing slightly larger than the type specimen (length 2.6 mm.) and with the venation very similar to it, but the shading around the pterostigma less extensive. The other forewing lies beneath it, so that some of the veins show through, making it somewhat difficult to follow the individual veins correctly.

Family LOPHIONEURIDÆ Till.

Lophioneuridae, Tillyard, 1921, p. 418.—Cyphoneuridae, Carpenter, 1932, p. 18.

The genus *Lophioneura* Till., 1921, was founded on a beautifully preserved forewing found in burnt shale from the railway embankment at Merewether Beach, Newcastle, N.S.W. It was placed in a new family Lophioneuridae and assigned to the Suborder Homoptera of the Order Hemiptera, with an indication that its affinities lay with the recent Division Sternorrhyncha and particularly the family Psyllidae.



Dr. F. M. Carpenter described the genus *Cyphoneura* in 1932, with two species from the Lower Permian of Kansas, one of which, the genotype, *C. permiana*, he claimed to be the smallest known Palaeozoic fossil wing, its length being only 1.9 mm. He placed his new genus in a new family Cyphoneuridae, allied to the Lophioneuridae, the principal differences being that in the Cyphoneuridae "Sc is more reduced, Rs and M arise more distad along R and 1A is independent".

In the new material before me from Warner's Bay, there are a considerable number of wings allied to both *Lophioneura* and *Cyphoneura*. One of these, a hindwing, measures only 1.5 mm. in length, and thus is considerably smaller than the forewing of *Cyphoneura permiana* Carp. and must therefore undoubtedly be the smallest Palaeozoic insect wing yet discovered.

A study of the new types shows at once that the two families Lophioneuridae and Cyphoneuridae cannot be maintained as distinct. All the types which possess a sigmoid Cu_1 and abnormal origins of Rs, M and Cu_1 should now be placed together in the family Lophioneuridae.

Further, specimens of these insects with the head, thorax and abdomen preserved show clearly that they were Copeognatha and not Homoptera. The head is depressed, with hypognathous mouth-parts and with no sign of a sucking-beak such as can be seen in the Permopsyllidae and other Permian Homoptera; the general form of body is copeognathous and the wings are held always in a steep roof-wise position. The forked Rs in both fore and hind wings is now seen to be definitely a copeognathous character, all the true Homoptera of the Permian having this vein simple except the heavily-veined Auchenorrhynchous Prosbolidae, where the distal forking of Rs is evidently secondarily developed. In the females, the abdomen shows no signs of an ovipositor.

Two new genera are represented in the collection before me; these may be distinguished from *Lophioneura* Till. and *Cyphoneura* Carp. by the following key:

Key to the Genera of the Family Lophioneuridae. (Forewings.)

1. Rs, M and Cu_1 arising rather close together from R, not far from base 2
 Rs, M and Cu_1 arising further from base, Rs at one-third or beyond 3
2. No clearly marked clavus or anal veins. R_1 straight apically
 Genus *Lophioneura* Till.
 A small clavus present, with short vein 1A. R_1 upcurved apically
 Genus *Lophiocypha*, n.g.
3. Sc present as a distinct vein. No connecting vein (basal part of Cu_1) uniting
 Cu_1 with Cu_2 Genus *Cyphoneura* Carp.
 Sc obsolescent or absent. A connecting vein uniting Cu_1 with Cu_2 near base
 Genus *Austrocypha*, n.g.

Genus 6. *LOPHIOCYPHA*, n.g. Figs. 7-9.

Characters generally of *Lophioneura* Till., but differing in the presence of a distinct clavus with short anal vein 1A well marked. The clavus makes a definite angle with the posterior margin of the forewing at the end of Cu_2 . Cu_1 is not so abruptly curved distally as in *Lophioneura*, but is gently sigmoid in curvature. Hindwings much shorter than fore, with R_1 very short, Rs and M forked.

Head depressed, hypognathous, with eyes rounded and wide apart. Thorax with well developed pronotum, meso- and metathorax closely fused together. Legs medium to strong. Abdomen much shorter than wings.

Genotype, *Lophiocypha permiana*, n. sp.

Horizon.—Warner's Bay. Upper Permian of N.S.W.

Key to the Species of Lophiocypha, n.g.

1. Clavus strongly angulated near base; wings distinctly hairy along margins *L. thysanella*, n. sp.
- Clavus not angulated; wings not distinctly hairy along margins 2
2. R_1 long, ending well beyond half-way; Sc very short *L. stanleyi*, n. sp.
- R_1 shorter, ending at about half-way; Sc well developed, ending just beyond level of origin of R_s *L. permiana*, n. sp.

7. *LOPHIOCYPHA PERMIANA*, n. sp. Fig. 7A, 7B.

Length of forewing, 2.75 mm.; breadth 1.0 mm. Distance from insertion of forewing on thorax to end of abdomen, 1.8 mm.

Head crushed down flatly from above; large and subglobular. Compound eyes both visible, circular, of moderate size, fairly well separated. Behind the eyes lies a large epicranial region, divided midlongitudinally by a well marked suture. Insertions of antennae small, lying well in front of eyes; two cylindrical segments of left antenna visible. A sclerite lying anterior to the antennae apparently represents the labrum, with indistinct signs of palpal segments projecting from one side of it. *Thorax* fairly large, the pronotum apparently short and wide; just in front of the insertions of the forewings are two curious embossments. *Legs* rather large and strong; only the middle and hind femora and hind tibia and tarsus are indicated, the latter faintly. *Abdomen* rather short, subcylindrical, with apparently ten segments, the first of which is small and indistinct; tenth

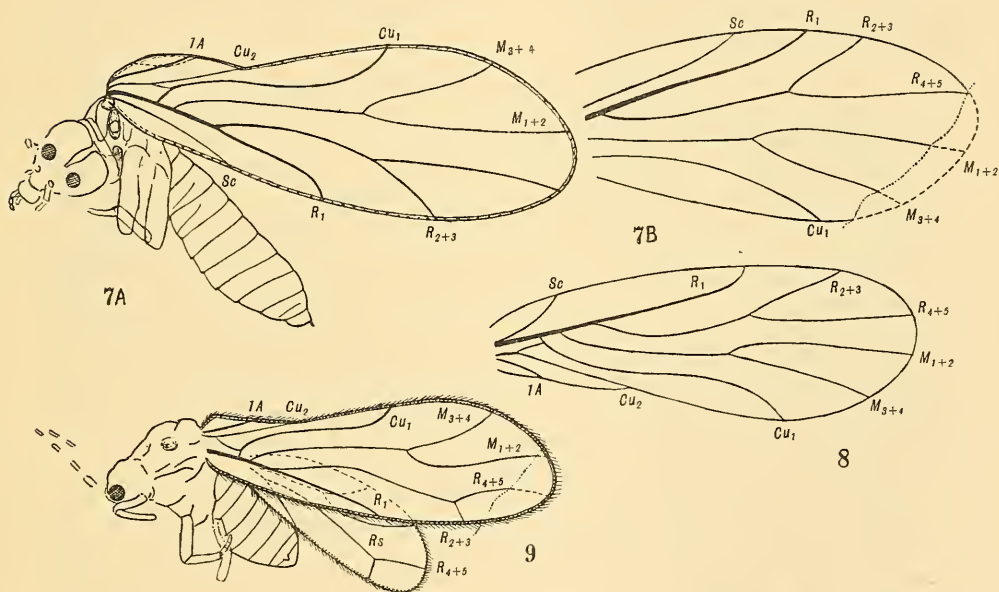


Fig. 7.—*Lophiocypha permiana*, n.g. et sp. A, Complete insect with forewing (2.75 mm.); B, Hindwing, with apex turned to right. Family Lophioneuridae.

Fig. 8.—*Lophiocypha stanleyi*, n. sp. Forewing (2.5 mm.) with apex turned to right. Family Lophioneuridae.

Fig. 9.—*Lophiocypha thysanella*, n. sp. Complete insect, with tip of forewing restored beyond the break (dotted line), and marginal hairs also restored. Length of forewing 3.2 mm. Family Lophioneuridae.

segment small, ending in a minute process which may have been an unjointed cercus. The specimen appears to have been a male.

Wings: Forewing as in fig. 7A. The margin appears to have been provided with strong sockets of macrotrichia, fairly widely spaced, suggesting a row of short, stiff hairs or setae. Sc ending at about same level as clavus, i.e., at one-fourth; R_1 ending slightly before half-way. Rs arising from R slightly before level of end of Sc, and forking at about half its length; R_{4+5} ending just above apex. M forking slightly before level of fork of Rs. 1A gently curved, ending just before half-way along the curved border of the clavus.

Hindwing (fig. 7B) lies slightly detached from the main specimen, its base being a short distance from the apex of the forewing and somewhat crumpled; most of it is well preserved. Length about 2.5 mm., breadth 1.1 mm. Sc and R_1 longer than in forewing; Cu_1 longer and less curved distally; no sign of a definite clavus or anal vein, but these may be hidden in the crumpled basal portion.

Type.—*Holotype*, Specimen S.16, found by Mr. Malcolm S. Stanley in rock collected at Warner's Bay in 1934.

8. LOPHIOPYPHA STANLEYI, n. sp. Fig. 8.

Length of forewing 2.5 mm.; breadth 0.9 mm. Apex to the left.

This species differs from the previous one in the much shorter Sc, the straighter and more sharply upturned R_1 , the narrower forks of Rs and M, the longer connecting vein from Cu_2 to Cu_1 , and the somewhat less prominent clavus.

Type.—*Holotype*, Specimen S.31, found by Mr. Malcolm S. Stanley in rock collected at Warner's Bay in 1934.

9. LOPHIOPYPHA THYSANELLA, n. sp. Fig. 9.

Length of forewing, 3.2 mm.; breadth 1.1 mm. Distance from insertion of forewing on thorax to end of abdomen, 1.5 mm.

Head depressed, hypognathous, of medium size, compound eyes (only one visible) fairly large, circular; fragments of four segments of one antenna and two of another visible, indicating that they were long and with numerous cylindrical segments. *Thorax* large and compact, but with the main subdivisions not well enough preserved to be distinguishable. *Legs* short and moderately stout; foreleg lying close up to head and showing short femur and tibia; middle and hind legs larger and stouter, the former showing femur, tibia and faint outline of short tarsus lying across femur of hind leg. An embossment lies in front of the insertion of the forewing. Abdomen short and stout, broadly fusiform; length only about one-fourth that of forewing. The specimen appears to have been a female from the shape of the abdomen, but there is no sign of an ovipositor, as would be the case if the insect belonged to the Homoptera.

Wings: Forewing as in figure 9. The whole of the wing-margin is pitted with strong sockets close together, indicating a strong fringe of marginal hairs. Sc is not visible but may nevertheless be present. R_1 runs straight, ending about half-way. Rs is curiously bent soon after leaving R, and its fork is short and terminal, shaped like an *areola postica*, R_{2+3} being a short, upward branch. M_{1+2} is more arched than in the two previous species, approaching more closely to the condition found in *Lophioneura*. The descending piece of Cu_1 is short and its connection with Cu_2 rather long and curved. Clavus short, ending at one-fourth, strongly angulated near base, with 1A strong and straight.

Hindwing projecting partly below forewing; much shorter, about 1.8 mm. long, with marginal hair-sockets as in forewing but weaker. R_1 short, ending

well before half-way. Rs with terminal fork similar to that of forewing; rest of venation not visible, hidden beneath forewing, except a portion of what appears to be M_{1+2} .

Type.—*Holotype*, Specimen P.K3, found by Mr. T. H. Pincombe, in rock taken from Warner's Bay in 1931.

Genus 7. *AUSTROCYPHA*, n.g. Figs. 10-12.

Forewings with well developed wedge-shaped clavus, Cu_2 running straight through in line with continuation of posterior margin distad. Sc absent or obsolescent. Area between costa and R rather wide. R_1 distally upcurved. Rs, M and Cu_1 arising fairly close together. Cu_1 connected with Cu_2 by a basal piece.

Genotype, *Austrocypha abrupta*, n. sp.

Horizon.—Warner's Bay. Upper Permian of New South Wales.

Key to the Species of *Austrocypha*, n.g.

- R_1 turned up abruptly at distal end; fork of M arising slightly before level of fork of Rs *A. abrupta*, n. sp.
- R_1 ending distally much less abruptly and nearer level of fork of Rs; forks of Rs and M arising at about the same level *A. barretti*, n. sp.

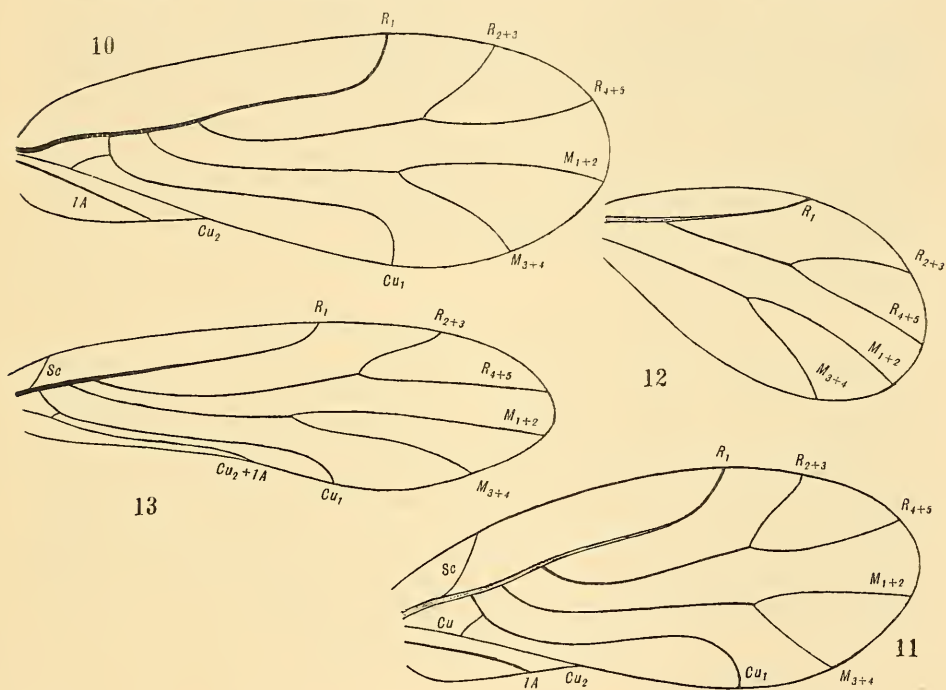


Fig. 10.—*Austrocypha abrupta*, n.g. et sp. Forewing (2.6 mm.). Family Lophioneuridae.

Fig. 11.—*Austrocypha barretti*, n. sp. Forewing 2.3 mm. Family Lophioneuridae.

Fig. 12.—*Austrocypha* sp. indet. Hindwing (1.5 mm.); probably belongs to *A. abrupta*, n. sp. Family Lophioneuridae.

Fig. 13.—*Lophioneura angusta*, n. sp. Forewing (3.2 mm.). Family Lophioneuridae.

10. AUSTROCYPHA ABRUPTA, n. sp. Fig. 10.

Forewing.—Length 2.6 mm.; breadth 1.0 mm.; clavus, 0.9 mm. long. Apex to the right. Sc absent. R slightly waved basally and near middle, then turning up very abruptly to meet costal margin almost at right angles at about three-fifths. M arising slightly nearer to Cu₁ than to Rs, the origin of latter vein at level of end of clavus or slightly beyond. Fork of Rs arises beyond level of end of R₁, the two branches wide apart. Fork of M arises only slightly distad from level of end of R₁, the two branches also wide apart. Cu₁ arising from R at right angles, its basal piece from R shorter than the connecting piece to Cu₂, which is arched. Cu₁ strongly curved sigmoidally and ending abruptly almost at right angles to the posterior margin. Cu₂ very straight. 1A strong, straight, diverging slightly from Cu₂, ending about two-thirds along margin of clavus. Clavus gently curved near base, then running straight to end of Cu₂ and ending in a sharp wedge making an angle of about 25° with Cu₂.

Type.—*Holotype*, Specimen A.35, found by Mr. Pincombe in rock taken from Warner's Bay in 1933.

11. AUSTROCYPHA BARRETTI, n. sp. Fig. 11.

Forewing.—Length 2.3 mm.; breadth 1.0 mm.; clavus 0.75 mm. long. Apex to the right. This wing differs from that of the previous species only in having a faint indication of Sc being present, in the less abrupt ending of R₁, in the slightly steeper origins of Rs and M from R, in having Rs and M both forking at about the same level, in the shorter connection between Cu₁ and Cu₂ basally, and in the slightly shorter and broader clavus. It is also of somewhat smaller size, and is actually the smallest forewing discovered in the Upper Permian of New South Wales, though not quite as small as the forewing of *Cyphoneura permiana* Carp., from the Lower Permian of Kansas (length 1.9 mm.).

Type.—*Holotype*, Specimen B.104, found by Rev. A. J. Barrett in rock taken from Warner's Bay in 1931.

Hindwing of the Genus AUSTROCYPHA. Fig. 12.

Specimen B.102, found by Rev. A. J. Barrett in rock taken from Warner's Bay, is the smallest wing ever found in any Palaeozoic strata. It is evidently a hindwing of the genus *Austrocypha*, and may be placed provisionally in *A. abrupta*, from the form and position of the forks of Rs and M.

Length 1.5 mm.; breadth 0.8 mm. Apex to the right. Base narrow, costal and apical margins evenly rounded, posterior margin only slightly curved basally. Sc absent. The only veins present are R₁, ending in a gentle upward curve just beyond half-way, Rs, arising not far from base, and running straight to fork at about half its length, and finally M, which is also straight basally and forks slightly before the level of the fork of Rs. No clavus present.

Genus 8. LOPHIONEURA Till.

Tillyard, 1921, p. 417.

Genotype, *Lophioneura ustulata* Till.

Horizon.—Merewether Beach. Upper Permian of New South Wales.

12. LOPHIONEURA ANGUSTA, n. sp. Fig. 13.

Forewing.—Length 3.2 mm.; breadth 1.0 mm. Apex to the right.

This wing differs markedly from that of the genotype, *L. ustulata* Till., in the greatly shortened Sc, in having R₁ slightly upturned distally instead of

straight, in the much longer forks of Rs and M, that of M being much narrower than in *L. ustulata*, in the much flatter Cu₁ with much less distal curvature, and finally in the basal half of the wing being much narrower, with the posterior margin slightly emarginate at end of Cu₂.

Type.—*Holotype*, Specimen S.K1, found by Mr. Malcolm S. Stanley, in rock taken from Warner's Bay in 1934.

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